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ABSTRACT

The capabilities expected of technological workers upon entry into employment were examined. Data were collected through a review of the pertinent literature and an in-person, instrument-guided interview survey of a representative sample of representatives of approximately 250 manufacturing enterprises in nine sectors. The literature review revealed six trends that led to the following conclusions: (1) recognition of the need to change from the "business as usual" mode is increasing; (2) workers are being expected to have a polyvalent arsenal of skills; (3) new forms of enterprise (work organization and hierarchy) are evolving and becoming more significant than the preceding forms; and (4) there is much confusion, fear, and tension among the workforce. According to the interviews, the extent to which the three core technologies were used in enterprises were as follows: communication and information technology, 48%; energy and power technology, 14%; and materials and processing technology, 38%. Although the employers considered foundational technological skills important, they did not consider them as important as employability and basic skills. There was little call for machine- and company-specific skills. Of the various additional targeted competencies deemed necessary, computer skills were the most frequently mentioned. (Ten figures are included. (Contains 19 references.) (MN)

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Trends in Industrial Skill Competency Demands as Evidenced by Business and Industry.

Michael J. Dyrenfurth

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Trends in Industrial Skill Competency Demands as Evidenced by Business and Industry[1]

Michael J. Dyrenfurth

Introduction

Education, at all levels, is all about developing understandings, perspectives, skills, and understandings. In today's technology-permeated world, education must inherently address technology -- for both general education and for career purposes. To do less, or not to address either of these purposes, is simply disenfranchising to both individual citizens and nations. From the perspective of corporate or private sector citizens, an absence of a systematic approach to both these purposes, while perhaps not disenfranchising, certainly undermines competitive potential.

Since, in all cases, and regardless of objective, education should be purposeful, the preceding demands that educators be clear about the outcomes engendered by the programs and experiences they implement. Recently much effort has focused on establishing a set of standards for technology education, at least the general education aspect of technology education, by the Technology for All Americans Project. Notable, however, is that there has not been an equivalent nation wide effort to establish the necessary career-relevant outcomes for technology education. What do the employers, who daily struggle to compete and survive in the global economy, expect of their employees? What competencies and understandings do they want their new hires to bring to the job? What competencies are needed to retain and even advance in today's employment world? In a prior work, this author wrote:

> Increasingly, economists and policy analysts are recognizing the crucial link between a state's economy and the capability of its people, i.e., its human resources. Given the evolution of business, economies and technology and the presence of unrelenting international competition, the previous relationship (which considered only capital and material resources) determining the strength of an economy is no longer valid. Instead, a new equation, one that recognizes the multiplier effect created by the collective capability of a state or nation's people, has emerged:
>
> GNP = Human Resources(Material + Capital)
>
> ...
>
> Gradually decision-makers are recognizing the existence of an entire continuum of technology involved workers, ranging from the semi-skilled through trades/crafts persons, technicians, industrial and engineering technologists, engineers, and scientists as shown in Figure 1. (Dyrenfurth, 1998, 1,6)

[1] This work has benefited from the effective contributions of many colleagues, including Dr. Bob R. Stewart, Dr. Daryl Hobbs, the directors and team members of the Kansas City, St. Joseph, State Fair Regional Technical Education Councils, and researchers Janet Paulsen, Tony Barbis, Klaus Schmidt, and Donald Watson.

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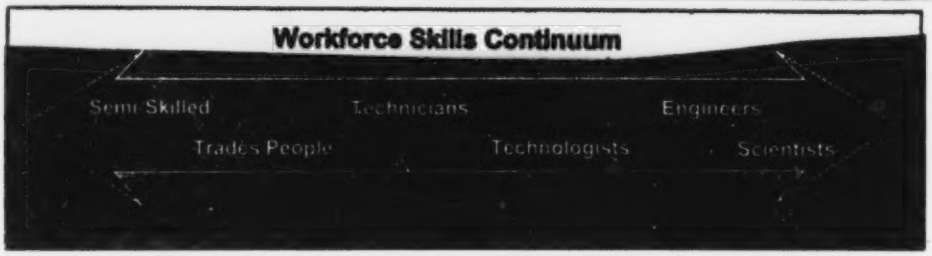

Figure 1. Workforce continuum

Problem

While this context is clear to many observers, the actual lack of clarity as to what the expectations of business and industry are is genuinely problematic to educators who are left with numerous unclear, poorly thought out, and often contradictory pronouncements. E.g., *Industry wants only generally educated (no technology preparation) persons who they can then train themselves...* or, *Industry wants people who are ready to assume productive roles from day one...* or *Just give me a person who is reliable and...*

The actual nature of the technological competencies expected of workers is not well known. Even the widely publicized and much revered SCANs report which focused so much on soft and basic skills is often misunderstood in that cursory readers have frequently overlooked that this report speaks of the SCANS-identified skills as being those needed **in addition to technological capability**. (SCANS, 1991, 1992)

The ability to do is at the heart of productivity and competitiveness. But what are the skills that constitute doing in a technological world? The absence of a clear answer to this question constituted the problem addressed by this study.

Purpose

Given the technology intensive dimensions of so much of today's work, the central purpose of this study was to identify the perceptions of incumbent manufacturing and related high-technology enterprise supervisors as to what competencies are of central importance to their new hires. The intent was to ascertain the nature and extent of competencies needed by crafts/trades and technical human resource needs in a mid-west USA region arcing around the eastern half of Kansas City from St. Joseph to Sedalia and extending southeast to Jefferson City, Missouri.

This purpose was addressed by conducting a targeted needs assessment focusing on manufacturing and other related technologies. The goal was to assemble a cogent picture synthesizing three separate needs assessments led by the author and conducted by research teams from the University of Missouri's Research Institute for Technical Education and Workforce Development. (Dyrenfurth, 1997, 1998; Dyrenfurth & Paulson, 1998)

Technological Competence

This paper seeks to answer questions about the kinds of capabilities expected of technological workers upon their entry into employment. As such, the conceptual foundations for this paper involved the concepts of technological literacy, the nature of competence, labor economics, and job distribution.

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Industry and technology-related enterprises exist to do -- to make, construct, service, communicate, and solve problems for customers or clients. Necessarily this requires people who are able to do[2], and through this, provide economic advantage[3]. The common term for such capability is competence. In this technological world, this author has posited that technological literacy constitutes the core of such competence.

Previously, this author provided a working definition for technological literacy as being:

- a multi-dimensional term that necessarily includes the ability to use technology (a practical dimension), the ability to understand the issues raised by or used of technology (civic dimensions), and the appreciation for the significance of technology (cultural dimensions). (Dyrenfurth, 1999, 108)

Readers should note that, when detailed, this construct incorporates a continuous set of levels, which range from initial levels of technological literacy (being largely awareness) to higher ones that involve real capability, even expertise.

In a paper commissioned by a major USA automaker, the author described seven key competency vectors that generate the technological literacy that is expected to be central to the success of future workers (Dyrenfurth et. al, 1989):

1. Teamwork & interpersonal skills/collaboration
2. Constructive work habits/values
3. Technological procedures
4. Technological capability
5. Basic functional skills
6. Thinking & decision-making skills
7. Ability to learn/adaptability/learning to learn

Competencies

This configuration of competency vectors extends the work this author published in Chapter 7 of *Technological Literacy* (Dyrenfurth & Kozak, 1991). It is particularly compelling to note the striking parallels across American and European (IRDAC, 1994) perceptions of the core competencies required for an effective workforce (Dyrenfurth, 1999). Similarly, Judy, Director of the Hudson Institute's Center for Workforce Development, in a speech to the AACC/NSF ATE Principal Investigators Conference, 11/21/98, Washington, DC, has cogently spoken to increasing employer calls for work ethic, people (teamwork, customer, leadership), and cognitive (language, mathematics, reasoning) skills.

In the research reported at the 1999 IWSSTE, this author wrote:

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[2] In a draft paper for RITE, Schmidt wrote, "Carnoy (1995) states that individuals acquire skills ... that enable them to produce more. These skills are directly related to the characteristics that labor needs so as to use other production inputs, namely capital and land, more efficiently (human capital explanation). Furthermore, people with more education tend to adopt new technology sooner and are more likely to make the economic changes dictated by the new technology (disequilibrium explanation). ...Such qualities ... improve productivity and therefore economic output." (1)

[3] According to Schmidt (1997), "The literature provides an array of models and approaches towards measuring economic impact of education. Two of the most widely cited researchers in the field of Human Capital are Becker and Schulz. While Becker (1964), approaches the value of education by means of both rates of return and effects on earnings, Schulz (1961) provides an insight on the economic return to various occupations and education classes. Carnoy (1995) adds a comprehensive international encyclopedia of economics of education with further foundations for economic modeling. This encyclopedia specifically depicts benefits of education, the evaluation of educational and training investment and financing aspects of education." (3)

The existence of a common core of technological skills and understandings is also suggested by the curriculum established by the NSF-funded NJCATE project (Waintraub, 1998) targeting on a multi-functional technician possessing what they term a Mecomtronics competency set. Similarly ACT's *WorkKeys*, H&H Publishing's *Mindful Worker*, and the *INCOTE-92* BMW Worker profiles presented by Buresch, all point in the same general direction. Returning to the previously used metaphor of the periodic table, our knowledge and theory pointed to the reality of some missing elements even though their existence had not yet been confirmed. SCANS also suggested the existence of a core but the promulgators of this report tended to focus on the core of soft or non-technical skills even though they, and this is often overlooked in their work, also acknowledged the existence and importance of technological skills. But, even though the popular treatment of SCANS focussed on what was postulated as a core of soft skills, would not the existence of one core suggest the possibility of the existence of another core - in this case, a technological one? (Dyrenfurth, 1999, 105)

People do not yet seem to have connected the possibility of the existence of a core to the solution to the issue and tremendous challenge of technological skill transfer in a world that seems to exhibit exponentially accelerating technological change. The real challenge before us is, I think, not to prove the existence of a core but the definition of its nature. Just what competencies make up such a core? (Dyrenfurth, 1999, 105)

Job Distributions

In addition to the lack of clarity about the nature of expected competencies, another poorly understood variable is the nature of the employment and business/industry in a state. What are the proportions between service and production jobs? What kinds of jobs are there and how do they distribute along the talent/preparation continuum. There has been a tremendous shift in the proportion of different types of jobs in technological societies such as the USA. Unskilled workers are projected to account for as little as 15% in the year 2000 and that managers are likely to shrink back to 20%. The amazing growth however, will occur within the ranks of the skilled and technologically capable people. (Bailey, 1989; Swyt, 1986; Dyrenfurth, et. al, 1998)

The importance of emphasizing technical education can be seen when examining the shifts in workforce demographics as documented by Bailey among others. Global competition combined with the technological revolution has resulted in a dramatic shift in the numbers of various types of workers as shown in the chart below (Figure 2). In the attempt to gain needed efficiencies and significant cost reductions, industry has drastically reduced the numbers of middle and higher management. At the same time there have been fewer and fewer opportunities for the unskilled and semi-skilled. The consequence is that more and more of the growth in employment is found in the middle technical ranks where qualified and highly capable workers are in a position to create considerable "value added" thereby justifying good wages. (Dyrenfurth, et. al, 1998)

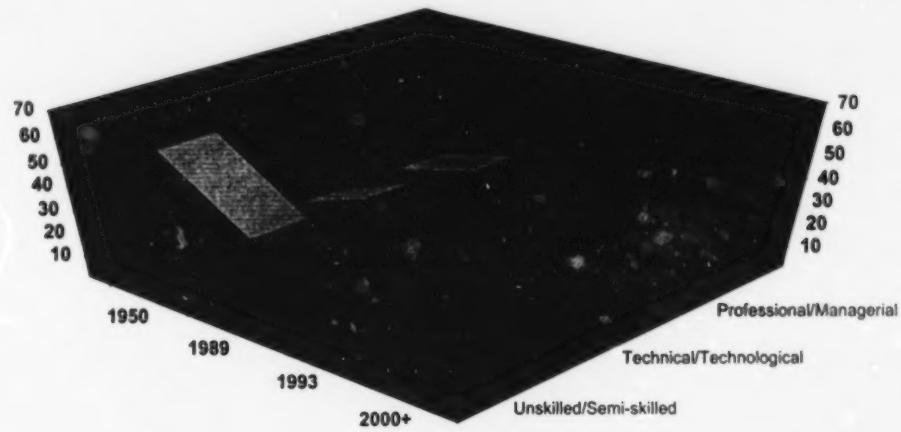

Figure 2. Shifts in workforce proportions

Methodology

Two methodologies were of central importance to this research. The first was that associated with the review of the literature that established the background and context for this study. The second methodology was that used to conduct the needs assessment and analyze the collected data.

For the literature review, *ERIC/CIJE*, *ABI/Inform*, and *Dissertation Abstracts*, databases were reviewed for relevant needs assessment information, as were the holdings of the University of Missouri library system. The procedure involved normal searches of electronic databases such as ERIC, including both documents and the *Current Index to Journals in Education*, and social science and management ones. The key search terms used were *technological literacy*, *worker skills*, *future skills*, *emerging skills*, *technological skills*. Several permutation and truncation variations of *skills* and *competencies* were employed in the search, as were those of *technical* and *technological*. In addition, to secure local data relevant to the needs assessment, the RITE team employed supplemental methods to access extant data, background documents, and research reports relevant to the technical education needs in the RTEC regions. These methods included discussion with community college and RTEC personnel; review of census, MALT, and Chamber of Commerce materials; OSEDA compilations as well as key Department of Elementary and Secondary Education (DESE), MOICC, and Department of Labor and Industrial Relations (DOLIR) documents.

To effect the needs assessment, the author conceptualized a straightforward needs assessment design that primarily employed an in-person, instrument-guided interview survey of employer information and perceptions focusing on the key questions to be answered. These, in overview, dealt with the numbers (current and projected) and kinds of trade and technical employees in the enterprise. In addition, questions were asked about required employee competencies, credentials, training, and trends. An overview of the general approach is depicted in Figure 3. Analysis subsequently involved frequency tallies and calculation of percentages.

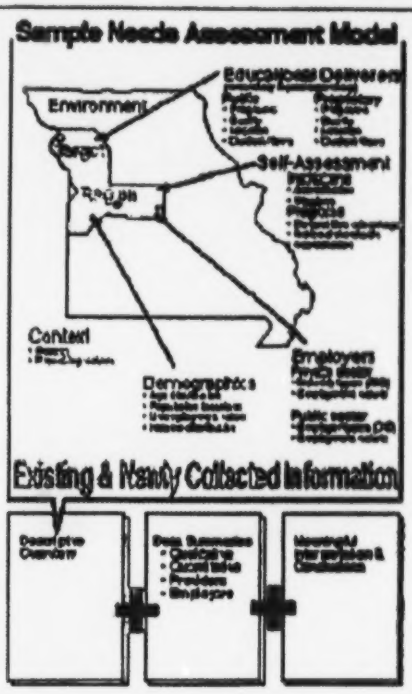

Figure 3. Needs assessment model

Population

The population for this compilation of needs assessments was defined to be all public and/or private sector enterprises, i.e., businesses, organizations, etc., that employ people in the geographic target region. Operationally this target region was bordered largely by the Missouri River on the west and the outskirts of Kansas City. The counties of Andrew, Bates, Benton, Buchanan, Camden, Cass, Clinton, Cole, DeKalb, Jackson, Lafayette (part), Miller, Moniteau, Pettis, Platte, and Ray were targeted. Approximately 1,100,000 people live in this region according to OSEDA's report of the 1990 census. It should also be noted that parts of adjacent Kansas counties; e.g., Atchison, Doniphan were included in some analyses but the population excluded Kansas City's metropolitan core. The region is principally served by the highway transportation axes of Interstate 28, 35, and 70. Its towns include: Blue Springs, Butler, Grain Valley, Harrisonville, Independence, Jefferson City, Kansas City (Eastern circumference), Lake Ozark, Lees Summit, Liberty, Odessa, Sedalia, and St. Joseph, among others. Enterprises in the target region were identified using Dun & Bradstreet listings. Confirmation of the primary target arenas, e.g., manufacturing, and related technology industries, e.g., hospitality, health and finance enterprises was accomplished by discussions among Kansas City, St. Joseph, and State Fair Regional Technical Education Councils and the RITE researchers.

Sample

A sample of approximately 250 industries to be surveyed was drawn from the population of enterprises in the target region. This representative sample was randomly selected on a stratified basis, using SIC codes and size. Approximately 10% of the region's population of enterprises having a significant probability of employing trade and technical personnel was sampled. Manufacturing enterprises were emphasized but not to the exclusion of other categories of enterprises that the literature suggested might be emerging employers of technicians.

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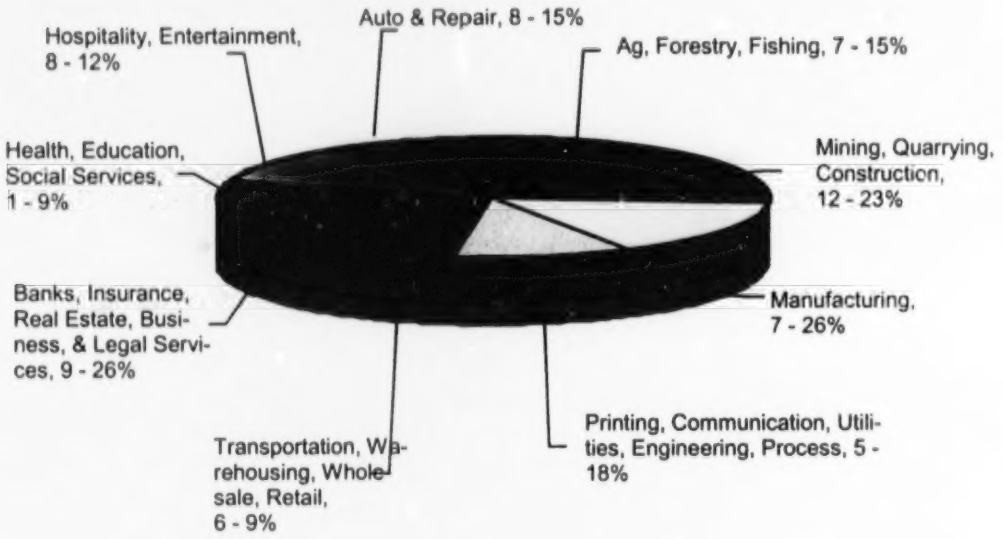

Hospitality, Entertainment, 8 - 12%
Auto & Repair, 8 - 15%
Ag, Forestry, Fishing, 7 - 15%
Health, Education, Social Services, 1 - 9%
Mining, Quarrying, Construction, 12 - 23%
Banks, Insurance, Real Estate, Business, & Legal Services, 9 - 26%
Manufacturing, 7 - 26%
Transportation, Warehousing, Wholesale, Retail, 6 - 9%
Printing, Communication, Utilities, Engineering, Process, 5 - 18%

Figure 4. SIC Code proportions of sampled enterprises

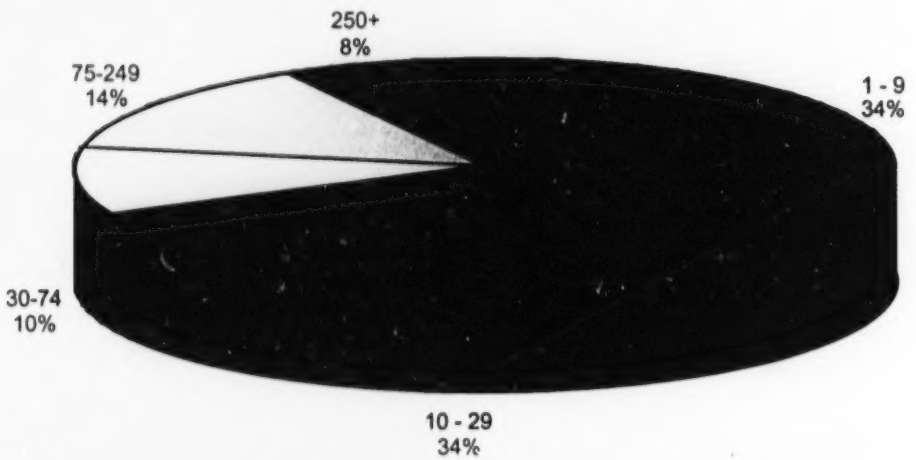


Figure 5. Proportions of employee size (number) range of sampled enterprises

Instrumentation, Data Collection, & Analysis

The needs assessment instrument consisted of a purpose-built, guided-interview questionnaire with provision for categorization of data while recording responses. The instrument was drafted after the RITE team first interacted with the collaborating regional teams to confirm the primary target questions. Several revision cycles were required until it was deemed ready for a pilot test. Training sessions were then held to finalize the instrument and to acquaint the involved parties with the interview protocol. Role-playing was used to effect the training and

thereby enhance the validity of the data and inter-interviewer reliability. The instrument was revised one last time and augmented with a set of explanatory attachments that served to generate more consistency by the respondents. The final instrument contained 15 questions that sought to capture the enterprise's nature, technology involvement, numbers, types and projections of employees, educational requirements, employee sources, turnover, competency requirements, trends, and training provision.

Data collection involved multiple interviewers each visiting contacts at their assigned enterprises. Typically, the interviewees were persons with operational responsibilities or someone with a key human resource development assignment. These enterprises had previously received a letter from a regionally collaborating institution explaining the overall intent of the survey and encouraging them to participate. Subsequently, telephone contact established an interview time. Then, one of the interviewers[4] visited the enterprise, introduced the survey as a collaborative RTEC effort. Pursuant to Human Subjects Informed Consent guidelines, interviewees were informed that participation was voluntary, that all information was confidential and that it would only be reported in a non-identifying manner. The data collection interview, guided by the survey instrument, typically involved 20-30 minutes and required interviewers to write responses into appropriate places on each survey form. In rare situations, when a meeting was delayed due to circumstances beyond control, an interview was conducted by telephone. After the RITE office received the completed surveys, their data were entered into a Filemaker Pro database for accessibility. Then, each respondent was sent a thank you letter.

Data collection also involved extraction of relevant information from accessible existing databases. The intent was to describe the educational programs, economics, demographics, employment, and needs within the target area. Several data sources were consulted to this end, primarily the OSEDA WWW postings, Census data, MALT reports, and the Coordinating Board for Higher Education's datafiles.

When the research questions were folded against the data collection methods, it became apparent that the initial analysis methods would be cross tabulation and, in a few cases, percent extrapolation. Given the focus of this paper on emerging skills expected of technological workers, only analyses and findings relevant to this objective will be reported herein.

Findings & Conclusions

Findings

The literature revealed six major trends bearing on the skills expected of the future workforce:

1. There is increasing emphasis on human resource development in both public and private sectors.
2. There is a shift towards worker empowerment.
3. Demographics are playing an increasingly larger role in HRD, employment, and corporate decisions.
4. Increased computer automation and integration will occur.
5. There is an ongoing shift from uniform mass production to flexible small batch production.
6. There will continue to be a significant human presence in manufacturing.

---

[4] T. Barbis, S. Bradley, S. Day, D. Degan-Dixon, M. Dyrenfurth, E. Gorsky, L. Lee, R. MacPherson, L. Oesteole, J. Paulson, G. Robb, B. Ross, K. Schmidt, B. Stewart

These six trends led to four major conclusions:

1. There is increasing recognition of the need to change from "business as usual" mode.
2. Workers are being expected to have a polyvalent arsenal of skills.
3. New forms of enterprise (work organization and hierarchy) are evolving and are becoming more significant than the preceding forms.
4. There is much confusion, fear, and tension among the workforce. (Dyrenfurth, et. al, 1989)

Technology Involvement

Interviewers sought to ascertain the extent to which enterprises used each of the three core technologies. The overall emphases are graphically depicted in Figure 6. Few companies understood the technological groupings listed on the survey. A considerable amount of time was needed to explain what each one was. Examples were given on the types of jobs in an organization where the technology may be used.

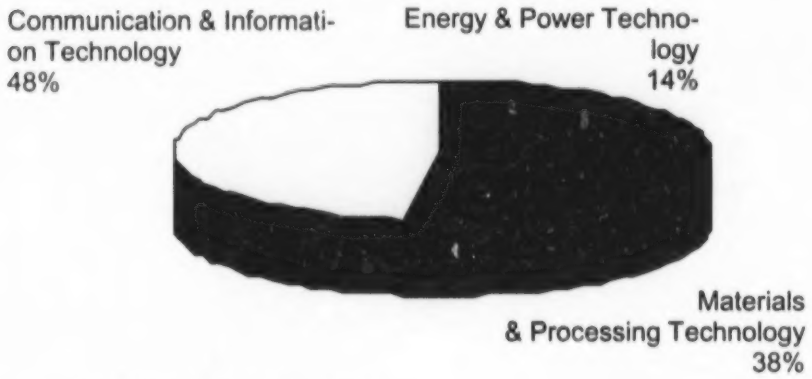


Figure 6. Proportions of enterprise technology involvement

Distribution of Worker Types in Workforce

Figure 7 shows the distribution of worker types, according to the continuum shown in Figure 1, in the sampled industries. Few respondents knew the definition of technician or technologist. The exception seemed to be people working in health care or the sciences. The researchers' impression was that there were several instances where it appeared that companies were hiring engineers and using them as technologists. Engineers appeared to be in adequate supply but technologists appeared to be in short supply. Both skill sets seemed needed.

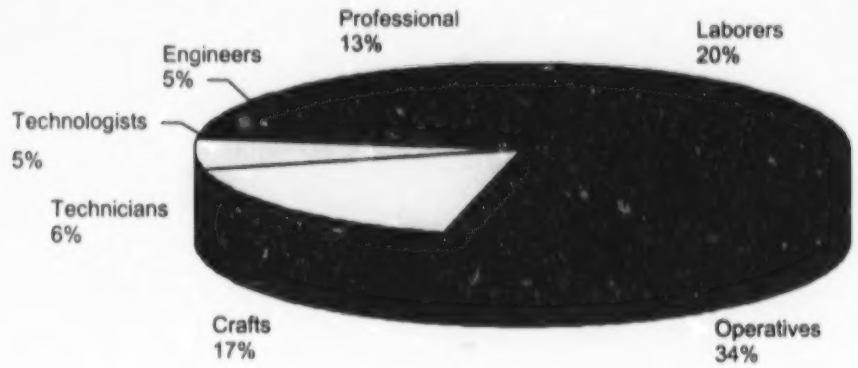


Figure 7. Workforce proportions in the sampled enterprises

Required education

Generally, high school graduation was the minimum acceptable level of education for entry workers on the continuum although the GED was typically referred to as a feasible equivalent. Typically, very little mention was made of less than baccalaureate (e.g., AA degrees) as a requirement for entry level work. The same, however, can be said for technologists with their baccalaureates. Journeymen credentials were sometimes mentioned for the relatively few crafts/trades positions in the companies surveyed. Little concern seemed to focus on the nature and quality of trade/craft training nor on the value of a post-secondary technical preparation. Nor were many industry certifications/credentials mentioned with any frequency. Overall, the researchers evolved the impression that experience and a positive work attitude were of far greater significance than educational attainment. Perhaps this is due to the tight labor market and rather successful economy most enterprises are experiencing.

Missouri is close to full employment. It is very difficult to find good workers who are not already working. As such, companies are placing fewer and fewer restrictions on their workers. In nearly every interview, job experience outweighed education when companies searched for replacement workers. Technical training did not rate highly in lists of job requirements. Often in the urban areas, business people believed that young people exiting trade and technical schools were not given the "right" kind of hands on training. In this case, "right" means applied training. Example after example was given of people who were "certified" by technical schools as knowing a particular skill, only to find later that they did not know it. One company described a situation where a new employee was fired for performing a procedure with serious consequences. When checking the educational institution's records, this worker had been "certified" as knowing the proper procedure.

Although not frequently cited as being necessary, industry based certifications were sometimes mentioned. Usually they were a plus although in several cases they were indeed a prerequisite to employment. Welding, corporate-specific, health, ASE, power engineer, and water certifications were among the most frequently mentioned.

Desirable skill groups

When employers were asked, "What are the most important skills/competency groups that your trade and technical personnel should possess?" (given the rating scale of Mandatory=3, Desirable=2, Prefer to train ourselves=1, and Not necessary=0) their responses, in Figure 8,

showed more understanding of the current situation they face than in previous studies. Employers did identify **foundational technological skills** as important although these were not rated as high as employability and basic skills. Notably they were rated considerably higher than specialization and machine specific skills. Little call occurred for machine/company specific competencies

Previously the principal author reported that "perhaps this occurred because employers recognized an increasing need for flexibility and adaptability in order to be responsive in fast changing times? The *Technological Foundation Skills* are critically important to engendering such capabilities. They are at the heart of one's ability to transfer capabilities to unfamiliar situations, to learn new technology, and to effectively troubleshoot problems." It seems appropriate to conclude that given three such findings, employers do perceive something of value here.

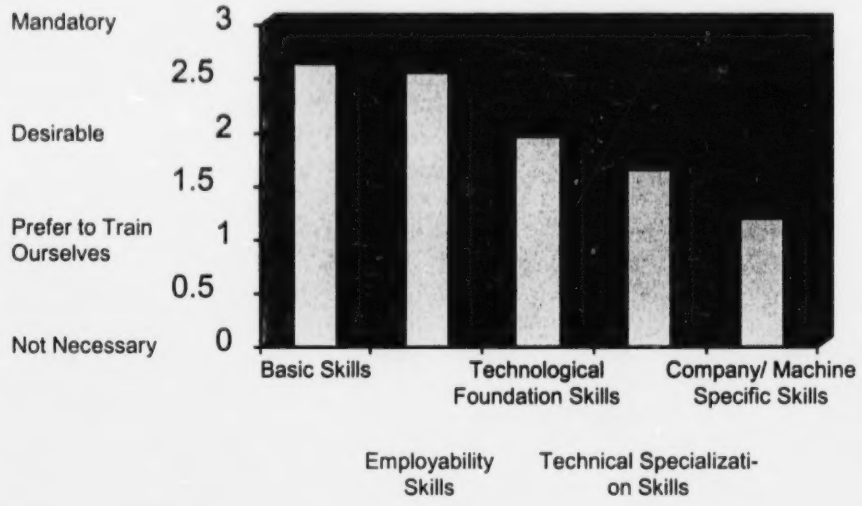


Figure 8. Employer ratings of competency group importance

Specific competencies

Consistent with past reports, the surveyed employers repeated their traditional calls for communication, calculation, and reading in the *Basic Skills* category. Teamwork, team/work group leadership/supervision reliability, learning-to-learn, and safety constituted the most called for employability skills. In the *Technological Foundation Skills* area, basic measurement, hand & machine tool use, preventative maintenance, technology systems overview, diagnosis, and technical troubleshooting/problem-solving were the most highly rated skills. Industrial automation related skills, industrial welding and industrial electronics were the highest rated of the technology foundation competencies.

Despite the absence of a strong call for a whole degree, or program, the employers certainly called for considerable development of targeted competencies. The *Technical Specialization Skills* competencies most frequently requested cluster around an emerging core that might be termed industrial automation and maintenance. Power transmission, control systems, PLCs,

sensors, technical trouble shooting, and systems views constitute some distinguishing aspects of this cluster of competencies. Little call occurred for *Company/Machine Specific Skills*.

Regional employers also mentioned an increase in applied mathematics needs, safety skills, and in something that might best be described as awareness of the economic consequences/implications of one's actions. Work ethics and attitudes were often cited as deficiencies of the current workforce. Strengthening of interpersonal skills and the development of a customer service orientation were important needs. Learning to Learn and a willingness/ inclination to do so also rated highly. To the researchers, it appeared that the nature of contemporary work increasingly calls for blended roles (multi-skilling), particularly among the mid- and smaller-sized enterprises.

The approximate frequency of mentions of the highest ranked competencies within each category are shown below (Dyrenfurth, et. al, 1997, 1998)

	Approximate frequency of mention
Basic Skills, e.g.:	
-Oral & Written Communication	78%
-Reading	67%
-Calculation	60%
-Citizenship	53%
Basic employability competencies:	
-Work reliability skills	83%
-Problem solving skills	74%
-Workplace safety skills	73%
-Teamwork skills (followership & leadership)	72%
-Learning to learn skills	67%
-Computer literacy skills	50%
Technology Core Competencies:	
-Preventive maintenance	60%
-Technical troubleshooting	60%
-Measurement skills	58%
-Basic hand tool & benchwork	52%
-Basic machine operation	51%
Advanced Technical Competencies, e.g.:	
None met the 50% mention criterion	
Company/Machine Specific Competencies:	
None met the 50% mention criterion	

A variety of additional competencies were called for but, by far, the most prevalent was the need for computer skills including effective utilization of both software and hardware. Generally, the context was one of applied usage of computers but basic operation and networking were also called for regularly. Associated with this is the need for machine control, e.g., PLC

and CNC, and electronics skills. Similarly, mechanical, sensor, and automation were more frequently mentioned than were traditional tool usage skills.

Specialty technical skills as needed by individual business were in demand but employers understood that educational institutions would not likely be in a good position to provide these. However, time management, estimating and scheduling, as well as a general awareness of the economic consequences of ones actions in the workplace were deemed important and feasible for educators to address. Industrial maintenance, both preventative and repair was called for also.

Reported urgent training needs paralleled the competency trends by identifying electronics, computer and software, team skills, technological problem solving, programming and machine control, specialized welding, safety, and maintenance (machine) as prime needs. Customer orientation and service, hydraulics, technological updates, and supervision were also mentioned as more frequent needs. Businesses would like for workers to come them fully trained but realize that they will need to train them themselves. Nearly all companies would pay for the training if they were to receive the benefit of the training.

It is one thing to specify a specific competency as needed or not, but there is more to competitiveness than merely identifying the "right" competencies. The performance standards or expectation levels used to assess mastery constitute a necessary ingredient. The surveyed employers are aware of this as were employers in a Kansas survey (Krider, 1996) of 600 enterprises. The latter found that skill requirements for entry level have increased but the actual skills of new hires have not kept pace, particularly at the operative and technician levels. Technology is expected to further increase actual skill level requirements. (71% increased slightly or significantly for entry-level jobs). Technology was reported to have a moderate or substantial impact on employee skill requirements by 67% of the KS respondents. 53% reported difficulty (moderate and/or extreme) in finding skilled employees. (page 17)

Conclusions

In previous work, this author described his model which demonstrates the nature of technological literacy. He posited that technological literacy is a key element to achieve efficiency in personal (familial), social, civic and also occupational spheres of activity. By mustering the forces of personal effort, maturation and systematic education; technological literacy is achieved by mastering the key essentials of: The ways of interacting with technology (technological procedures); and technology's core capabilities within each of the three primary domains of technology (energy & power, materials & processing, and communication). All of these, of course, build on a solid base of general education (basic functional skills). Teamwork, constructive work habits, and critical thinking skills are reinforced by their technological applications. The synthesis of these capabilities results in increased capacity for "learning-to-learn." Then, as people advance, the requirements for technological literacy escalate as people assume positions with ever increasing responsibility. In general, the findings of these needs assessments support the appropriateness of the model.

Validating the continuum

A set of studies conducted (1997 & 98) by the author and a team of researchers confirmed the existence of the aforementioned human resource continuum, at least for a multi-county area skirting the northeast and southeast area around St. Joseph, Kansas City, and Sedalia, Missouri. In addition to establishing the existence of the continuum shown in Figure 1, this research project also established the actual proportions (Figure 7) of workers along the continuum.

Furthermore, the interviews also sought answers to the private sector's perceptions as to the relative importance of five hypothetical skill categories that together form the capabilities of a person. The relative importance ratings of the five skill categories are shown in Figure 8.

Awareness of the continuum

All three regional needs assessments found that employers did not demonstrate much awareness of the newer positions, e.g., technicians & technologists, along the continuum of technical human resource development. Employers also evidenced relatively little awareness of, or demand for, sub-baccalaureate education in the technical realm or even for degreed technologists. Other than union apprenticeship, there was relatively little report of demand for sub-baccalaureate education in the technical realm or even for degreed technologists.

Competency trends

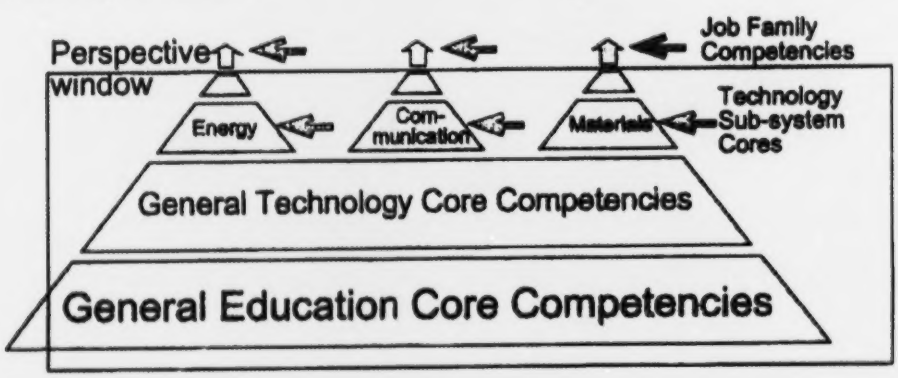
There was clear evidence that employers did indeed consider technological foundation skills to be important for their employees. Given their interest in pre-hire skill development, this should be an important part of the schooling at both the public school and college levels. Note that this is somewhat contradictory to conventional wisdom that suggests that all employers want are basic and employability skills and "they will train the rest!" Employers, of course, continued to rate employability and basic skills as essential prerequisites for employment. However, they also rated technological foundation skills as important, probably because these are at the heart of one's ability to transfer capabilities to unfamiliar situations, to learn new technology, and to effectively troubleshoot problems.

Validating the competency model

Employers' responses suggested that technology relevant competencies could indeed be envisioned as hypothesized and as shown in Figure 9. (Dyrenfurth, 1999)

Nature of need for personnel

The research did not surface a clear or overwhelming demand for any single specific technician and/or trade education program. Instead, in the surveyed regions, the need that does exist is very widespread, diffuse, and diverse. The call for technical education/training was not focused. There was, however, a widespread call for skilled and competent people capable of contributing to the employers productivity and competitiveness. It just seemed that the employers surveyed did not associate such outcomes with graduation from either secondary or postsecondary education.



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1. Basic skills	General education core competencies
2. Affective work competencies	Primarily General education core competencies and General technology core competencies
3. Technology fundamentals	General technology core competencies
4. Technical specialization skills	Technology sub-system cores
5. Proprietary/High-end technical skills	Technologically very specialized competencies

Figure 9. Hypothesized skill categories and multilevel core competencies

Recommendations

Nature of technology education

We need to change the nature of our technical education programming from one that primarily builds limited numbers of discrete skills to one that develops a stronger foundation of technological literacy necessary for flexibility and adaptability. Enhanced amounts of the more important discrete skills and understandings must also be taught. Concurrently, we need to inculcate a strong base of academic skills that enhances articulation and subsequent other use of this education. The traditional approach needs to be re-oriented to yield more demanding set of programs that bring more people to higher levels of performance in more ways. This goal is depicted in Figure 10. (Dyrenfurth, 1998)

It bears repeating. Not only are higher levels of performance called for as depicted by the vertical gain highlighted in Figure 9, but also the actual nature of technical education programming needs to be changed to yield increased performance in high level cognitive skills such as analysis, synthesis, evaluation, technological problem-solving, transferability, adaptability and flexibility.

Because the surveyed employers emphasized more of a need for competencies than completion of an entire program, the researchers recommend that institutions consider modularizing their courses even more than is currently the case. The recommendation is to enable interested parties obtain training with less of a time commitment than what a typical semester course involves by developing a diverse series of modular learning opportunities that each carry credit but that are completely flexible in duration, level and location. These Competitive Skill Modules (CSMs) must be constructed to be cumulative, i.e., add to become the equivalent of university, community college, or secondary technical courses. The CSM competencies must all be derived from high demand, high criticality, occupations, and competencies such as those identified by this and other surveys. Modularization could also facilitate more flexible scheduling of learning experiences to better suit the varied needs of the clientele.

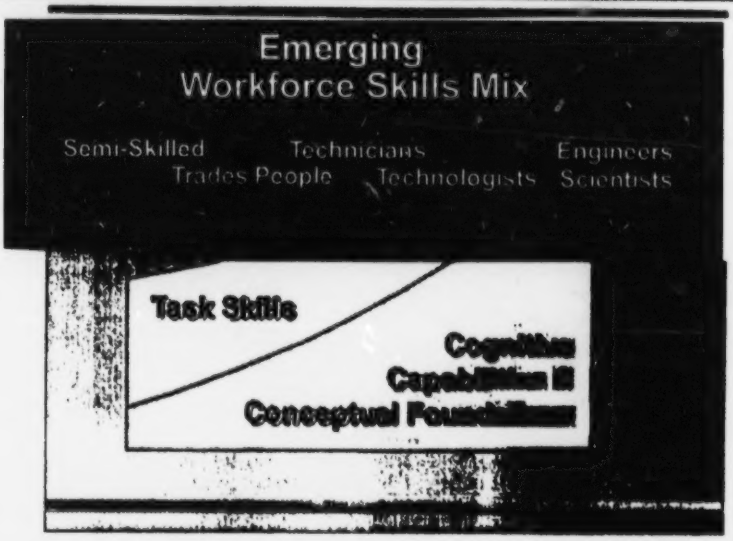

Figure 10. Nature of needed programs

The aforementioned approach has the advantage that, rather than committing to and implementing an entire specific program, it allows a much less risky strategy of "growing" selected trade and technical education programs by first building a successful track record of short-term, industry-driven interventions using the CSMs. Then, when demand develops to the point where critical mass is available, a formal, full-scale program can be implemented if desired. It is also recommended that, by building on industry trainer forums, sustainable critical mass can be generated by forming industry collaboratives to use, guide, and offer coherent training programs of 1, 2, and 3 year durations.

Certification of technological competence

It is also recommended that the educational program/course/module developers actively work to incorporate existing and emerging industrial certifications into the design of their learning/assessment experiences. Educational planners are encouraged to make greater use of industrial certifications/credentials and training opportunities as they design new learning/assessment experiences. Design new, more useful ones and above all, mechanisms for assessing, certifying and aggregating them into meaningful groups.

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